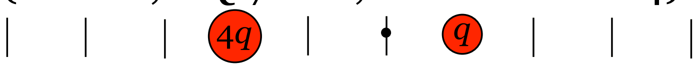
Announcements

- Homework for tomorrow…

  (Ch. 26, CQ 7 & 8, Probs. 12 & 14)

CQ2a): 

b): 

26.4: $E = 7.6 \times 10^3$ N/C, 90^o below the horizontal

26.6: a) $q = 2.0 \times 10^{-9}$ C b) $E = 180$ N/C

Office hours…

MW 10-11 am

TR 9-10 am

F 12-1 pm

- Tutorial Learning Center (TLC) hours:

  MTWR 8-6 pm

  F 8-11 am, 2-5 pm

  Su 1-5 pm

Chapter 26

The Electric Field

(*The E-Fields of Rings, Disks, & Planes*)

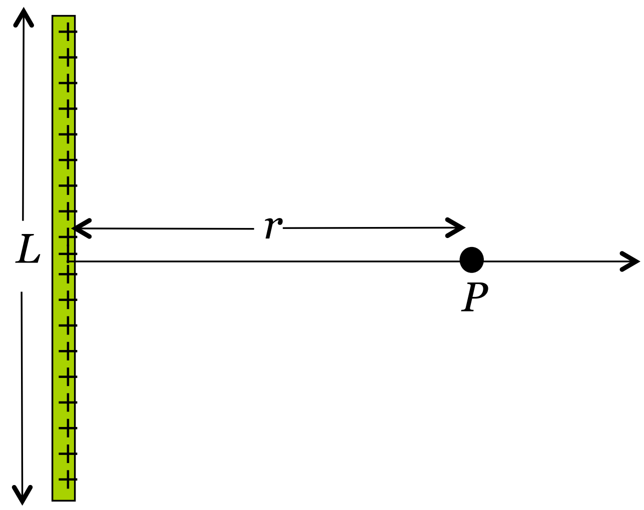
Last time…

- *Linear & surface charge densities*

$$\lambda = \frac{Q}{L} \qquad \eta = \frac{Q}{A}$$

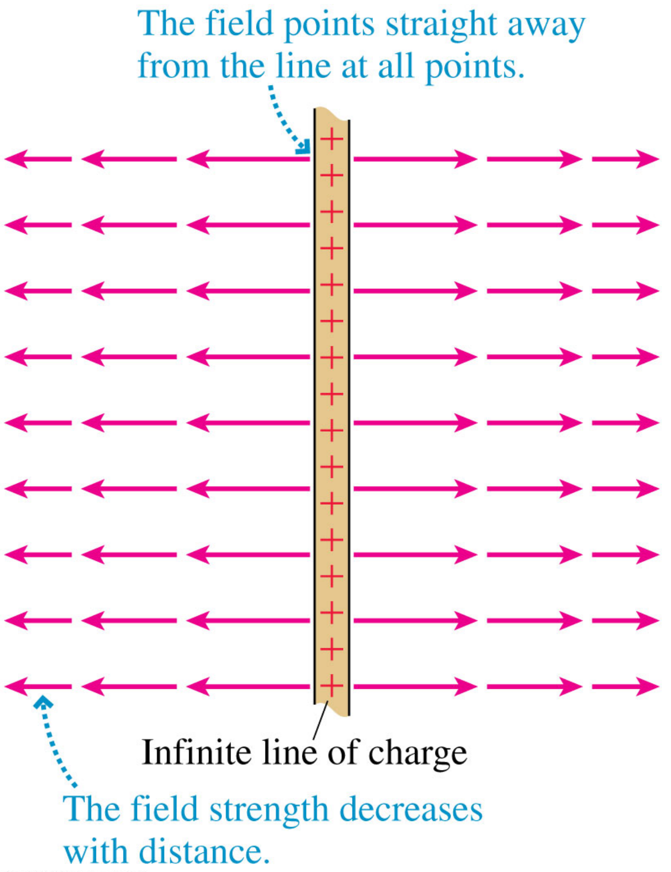
- *E-field* of a *rod* of length L & charge Q in the *bisecting plane*..

$$E_{rod} = \frac{1}{4\pi\epsilon_0}\frac{Q}{r\sqrt{r^2 + L^2/4}}$$



- Q: What if we get *really far away*?
- Q: What if the rod becomes *infinitely* long?

E-field of a line of an infinite line charge..

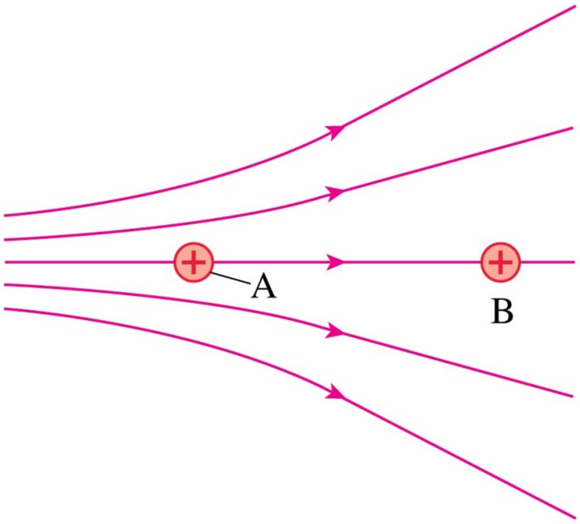


$$E_{line} = \frac{1}{4\pi\epsilon_0}\frac{2\lambda}{r}$$

Quiz Question 1

Two protons, *A* and *B*, are in an *E*-field.

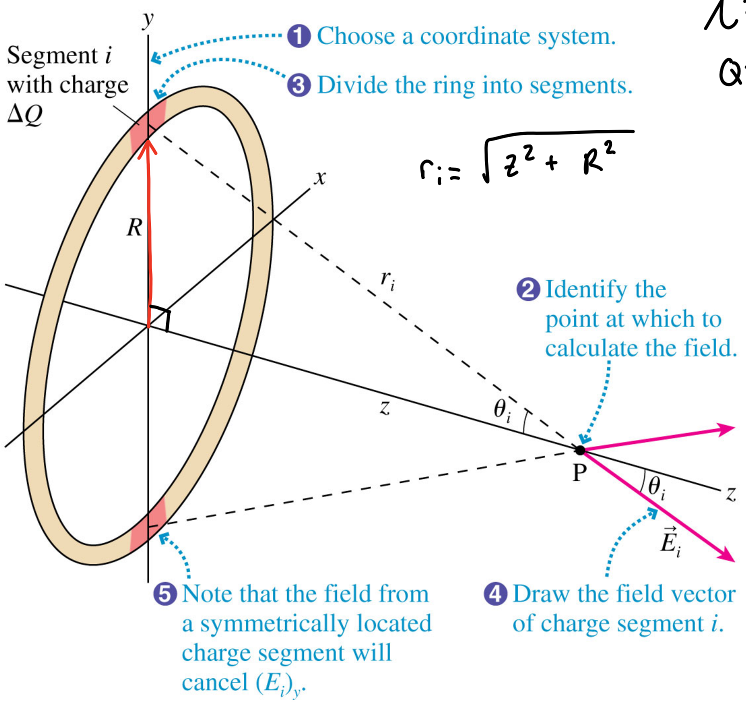
Which proton has the larger acceleration?



1. Proton *A*
2. Proton *B*
3. Both protons have the same acceleration

i.e. 26.4
E-field of a ring of charge..

A thin ring of radius *R* is uniformly charged with total charge *Q*. Find the *E*-field at a point on the axis of the ring.



$$r_i = \sqrt{z^2 + R^2}$$

$$\lambda = \frac{Q}{2\pi r}$$

$$Q = 2\pi r(\lambda)$$

$$dE = \frac{K\,dQ}{z^2 + R^2} \qquad dE = \frac{Kz\,dQ}{(z^2 + R^2)^{3/2}}$$

$$\cos\theta = \frac{z}{\sqrt{z^2 + R^2}}$$

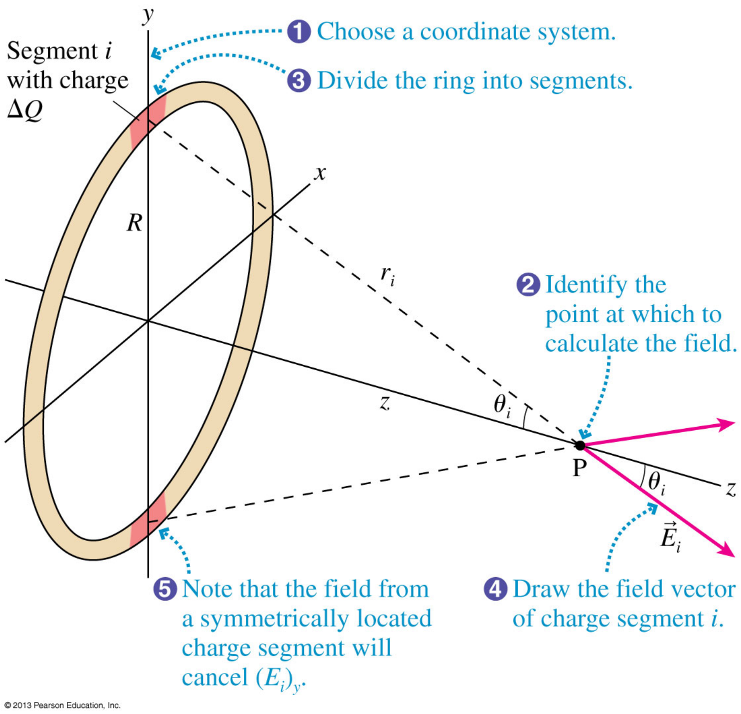
Total E Field

$$E_z = \int \frac{Kz\,dQ}{(z^2+R^2)^{3/2}} = \frac{Kz}{(z^2+R^2)^{3/2}} \int dQ$$

$$dQ = R\lambda\,d\phi \qquad \vec{E}_z = \frac{KQz}{(z^2+R^2)^{3/2}}$$

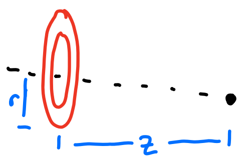
i.e. 26.4
E-field of a ring of charge..

A thin ring of radius R is uniformly charged with total charge Q. Find the E-field at a point on the axis of the ring.



$$\boxed{\vec{E}_{Ring} = \frac{1}{4\pi\epsilon_0}\frac{Qz}{(z^2+R^2)^{3/2}}\hat{k}}$$

- Q: What about for $-z$?
- Q: What about for $-Q$?



$$\vec{E} = \frac{KQz}{(z^2+R^2)^{3/2}}$$

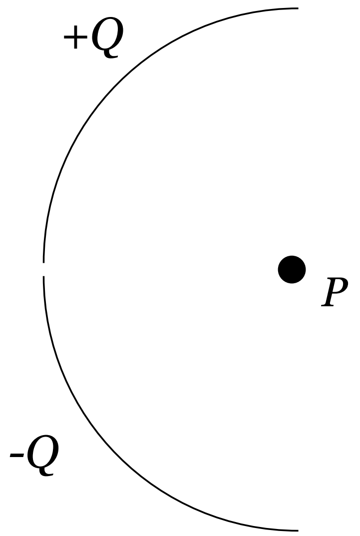
z = distance from ring to point

R = Radius

Quiz Question 2

Positive charge, $+Q$, is uniformly distributed on the upper half of a semicircular rod and negative charge, $-Q$, is uniformly distributed on the lower half.

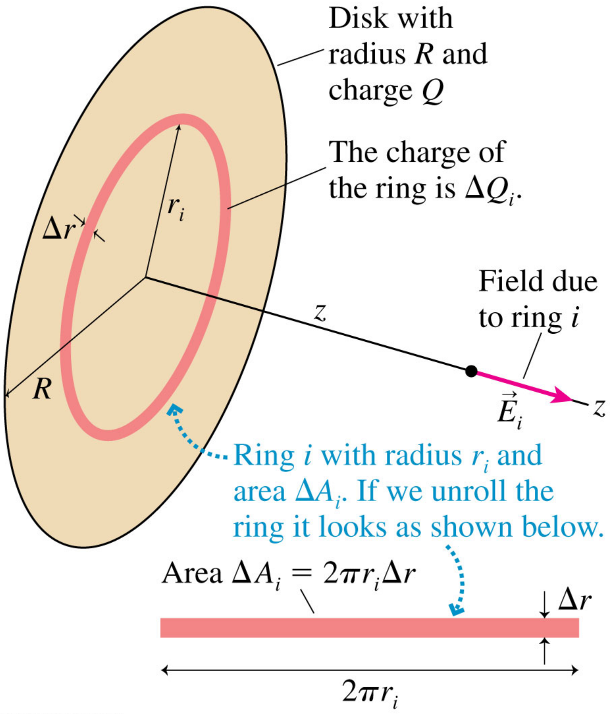
What is the direction of the electric field at point P, the center of the semicircle?



1. Up.
2. Down.
3. Left.
4. Right.
5. Down and to the left.

E-field of a disk of charge..

A disk of radius R is uniformly charged with total charge Q. Find the E-field at a point on the axis of the disk.



$$\eta = \frac{Q}{\pi r^2}$$

$$Q = \eta(\pi r^2)$$

$$dQ = \eta(2\pi r\, dr)$$

$$dE_z = \frac{Kz\, dQ}{(z^2+r^2)^{3/2}}$$

$$dE_z = \frac{Kz\,\eta\, 2\pi r\, dr}{(z^2+r^2)^{3/2}}$$

$$E_z = \int \frac{Kz\,\eta\, 2\pi r\, dr}{(z^2+r^2)^{3/2}}$$

$u = r^2 + z^2$

$du = 2r\, dr$

$\frac{1}{2} du = r\, dr$

$$= 2\pi K z \eta \int_0^R \frac{r\, dr}{(r^2+z^2)^{3/2}}$$

$u^{-3/2}$

$-2u^{-1/2}$

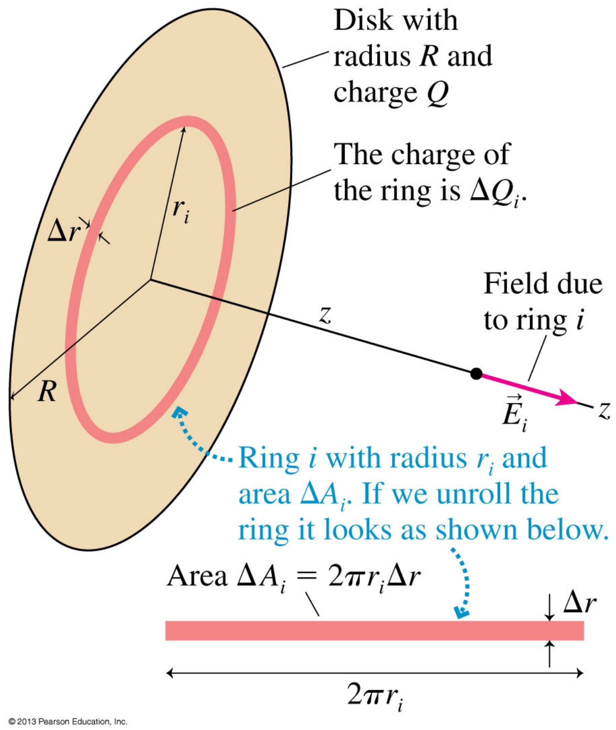
$\frac{-2}{\sqrt{r^2+z^2}}$

$$= 2\pi K z \eta \int_{z^2}^{R^2+z^2} \frac{1}{u^{3/2}}\, du$$

$$\frac{\eta}{2e_0}\left[1 - \frac{z}{\sqrt{z^2+R^2}}\right]$$

E-field of a disk of charge..

A disk of radius R is uniformly charged with total charge Q. Find the E-field at a point on the axis of the disk.



$$\boxed{\vec{E}_{disk} = \frac{\eta}{2\epsilon_0}\left[1 - \frac{z}{\sqrt{z^2+R^2}}\right]\hat{k}}$$

$$\frac{\eta}{2e_0}\left[1 - \frac{z}{\sqrt{z^2+R^2}}\right]$$

Notice: $\eta = \frac{Q}{A}$ z= Distance to point
R= Radius of disk

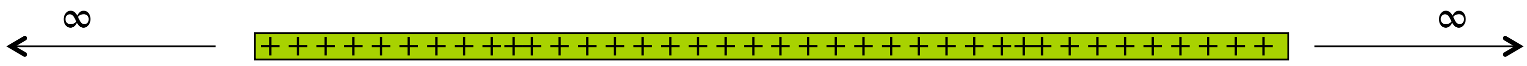
- For $z<0$, *same magnitude* but *opposite direction*

$$E_{Disk} = \frac{\eta}{2\epsilon_0}\left[1 - \frac{z}{\sqrt{z^2+R^2}}\right]$$

z=distance to point
R=Radius of disk

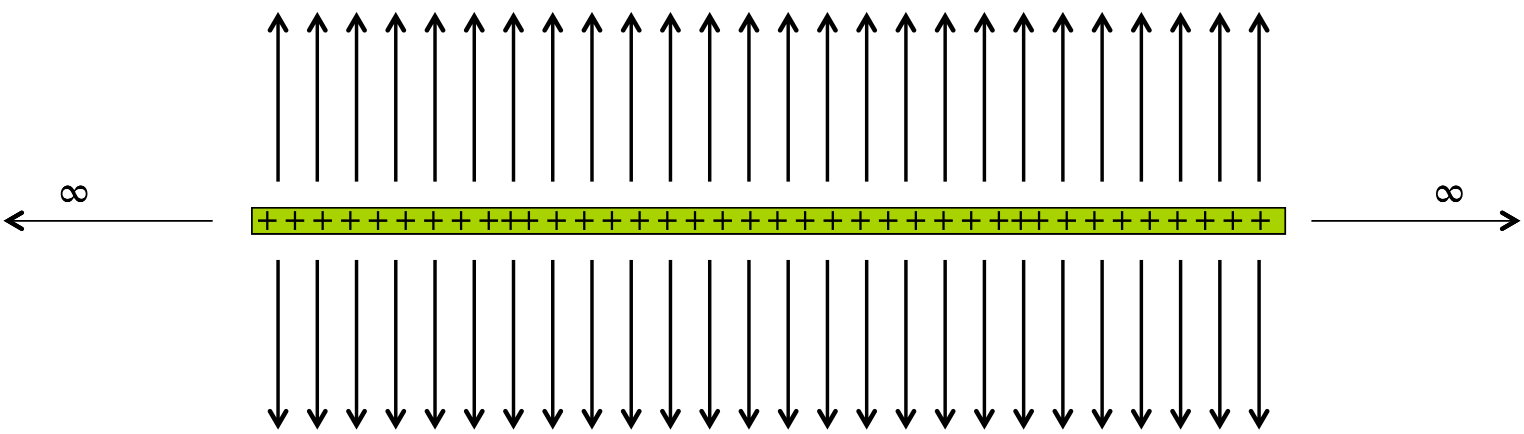
E-field of a plane of charge..

A plane is uniformly charged with uniform surface charge density η. Find the E-field…



E-field of a plane of charge..

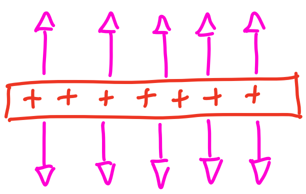
A plane is uniformly charged with uniform surface charge density η. Find the E-field…



$$\boxed{E_{plane} = \frac{\eta}{2\epsilon_0}}$$

Notice:

- A *constant*!
- Zero height dependence?



$$E_{Plane} = \frac{\eta}{2\epsilon_0}$$